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THE SCIENCE OF CHANGE OF AIR

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SCIENCE OF CHANGE OF AIR.

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PREFACE.

In presenting the following pages, I desire to take the opportunity of stating that if, in making any quotation or statement, I have neglected to give the name of my authority, that the omission was unintentional. I am greatly indebted to the writings of Carpenter, Kirkes, Fox, Wilks, Green, Shapter, and others.

THE AUTHOR.

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THE

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CHAPTER I.

PHYSIOLOGY AND RESPIRATION.

In order to arrive at a correct understanding of the intentions of the following pages, it will be essential to consider somewhat the anatomy of the lungs. Not to enter too deeply, but yet sufficiently to enable the uninitiated to appreciate the subject. For it will be desirable, not only in the healthy condition to be, if possible, familiar with the lungs, but in some of the various phases attending the diseased state, or the partially arrested action.

The beautiful mechanism of respiration which enables us to enjoy our lives, if obstructed for only a very short period, causes that life precipitately to cease. The air must be able to obtain entrance; the lungs must be in a condition to receive; the quality of the air must be good, or the healthful function cannot be satisfactorily carried on. First, then, the

air must be able to obtain entrance. Mechanical obstructions from violence may well be left out of consideration as not having any bearing upon the subject. Obstructions from disease are in some instances of an acute nature, and are not concerned in the question of change of air, excepting as an after subject of treatment. The passages leading into the air cells of the lungs must be clear and free, and the cells must be in a condition to act under the stimulus of the air.

The lungs must be in a condition to receive. The minute but multitudinous air cells of the lungs are the chambers where the chemical process of respiration—the transformation scene of life—is performed. Each minute chamber is a complete laboratory in itself; is provided with numerous, still more minute, cells of epithelium, the natural covering of the mucous membrane, whose wall is so delicate and thin that the essential constituent of the air can pass through it into the blood, the vessels conveying the latter forming a network in the walls of the chambers. The particular epithelium lining the mucous membrane of these air cells is what is called the pavement or tesselated kind; it is in the form of six-sided plates, the edges being adapted to, or slightly overlapping one another, and thus forming a species of mosaic tiling. It differs in character from that of the mouth, nose, and bronchial tubes; the latter being a columnar species, crowned with ciliæ or processes which are continually on the move, so as to assist in passing any extraneous or useless material towards the natural outlet. The epithelium of the air cells has

its counterpart in the most delicate organ of special sense, the choroid coat of the eye. It is within these cells that a chemical transformation is conducted. Some of the oxygen of the air unites with the carbon in the blood in the body, and is exhaled as carbonic acid; some unites with hydrogen to form water. Thus, air which has been inspired comparatively dry and healthy returns in a totally different condition; with an injurious quantity of carbonic acid, and loaded with watery vapour.

It is with the latter condition that the following pages will be more particularly concerned.

The quality of the air will naturally come under the head of Climate and Topography. The subject of the expired carbonic acid has been a long and oft-debated problem in reference to crowded assemblies, but the question of the amount of watery vapour has been less noticeably dwelt upon, and yet it seems as if it must be an important item.

The lung in a healthy state then gives off certain products of chemical action.

The estimated amount of laboratory power, or the surface of lung available for action, will vary with the size of the individual. In a man of average height and development it is calculated to be an area of 64 square yards. In a diseased state a very large surface may be cut off; the healthy function being impaired and diminished accordingly.

The diseases of an acute character affecting the lungs, being of a short and transitory nature, have less bearing on the object I have in view than the slow or chronic conditions. In active inflammation,

such as acute pneumonia, the actual corpuscles and fluid of the blood escape from the extremely small and delicate vessels in such quantity as to completely compress and block up the air chambers, and tissues surrounding them, so that air cannot enter.

These minute capillaries of the circulation (which form the connecting link between arteries, conveying blood for use in the system, and veins, conveying blood which has performed its functions) are the vessels where the actual work is performed. They are rather channels in the tissues than vessels properly so called, and have, it is supposed, only cells of pavement epithelium, called, in this case, endothelium, for their walls.

During the progress of the inflammation the corpuscles of the blood so come crowding together that the capillaries cannot contain them, and they thus force the edges of the cells to separate and allow of the blood passing between them into the surrounding tissues. In the lungs, the effect is to render the inflamed portion a consolidated mass of compressed and choked air chambers instead of an elastic spongy substance. Ultimately the solidity may disappear and healthy capacity be restored. The bloodvessels concerned in the inflammatory process being the the vessels of nutrition more than those peculiar to the respiration. The illness is regarded as a general disease affecting the whole system, the pneumonia being a localized expression.

In chronic conditions the action is altogether different, and it is with these that the question of climate, change of air, is concerned.

In the acute conditions of disease a large portion of the lung is rapidly affected; in the chronic, a small portion may become suddenly so, the narrow bronchial tube being so choked with mucus that air cannot pass through. The action is really a secondary one, following a previous disease. Thereupon ensues an inflammation and a peculiar change in the air chambers and epithelial cells. This inflammation is of a totally different character to the acute. There is no passage of blood corpuscles into the surrounding tissues, but the epithelial cells are immensely increased in number so that the chamber becomes completely blocked with them. There is a slow, semi-stagnant condition of the blood in the parts immediately surrounding the cut-off, or collapsed piece of lung; vitality soon becomes impaired, and the small bit of lung destroyed, unless the offending tube permit the air to pass. It is altogether a local and not a general disease.

In studying the results of the two diseases, the acute and chronic, we see that the air chambers are gradually more and more compressed, according to the length and severity of the acute attack; the air is able, though in gradually decreasing amount, to obtain entrance into and exit from the chambers, and the epithelial cells are able to carry on their functions, though in a less degree. In the chronic conditions, where the air chambers are suddenly cut off from the air, the minute cells are not able to obtain exit. In the healthy state, these cells are being continually shed, and are exhaled in the respiration in great numbers, but in the above condition, although they

are shed, they cannot escape, and thus rapidly fill and block up the air chambers where they are imprisoned. Oxygen not being able to obtain entrance, chemical action cannot be carried on, and the life of the affected part is in abeyance. Carbon is retained, and the separation of hydrogen in the form of water cannot be effected, but the latter is ready to combine with other elements of the body, sulphur and phosphorus, in the action of decomposition, or rather, putrefaction. We thus see the immense importance in the animal economy of the formation of watery vapour in the process of respiration, that hydrogen may be removed from the system instead of being retained to assist in destructive processes.

The products of this special action in the air chambers must be got rid of in the form of phlegm, before the parts can be restored to a healthy state. The tendency of this chronic condition is to set up a gradual change in the lung. The above are instances where the lung, previous to the inflammation and first disease, has been in a healthy condition. There is also the state where the lung itself is previously affected with minute deposits which may gradually affect the surrounding tissues, and tubercular disease, consumption, be slowly making its way.

It is true that these small deposits may lie dormant for a long time, but if inflammation arise and implicate them, then they may be roused to dangerous activity. It may also happen that consumption without the presence of tubercle may follow an attack of the diseases previously mentioned.

We require then a delicate mechanism in a healthy

state for the due performance of the chemical and mechanical requirements of respiration.

The climatic conditions best suited for that should form the basis of our inquiry concerning change of air. A small excess of carbonic acid in the air to be inspired materially affects the exhalation of it during respiration ; the process is checked, notwithstanding that the oxygen of the air is still in good proportion ; but where that has been greatly consumed, as in closely crowded assemblies, then the formation of carbonic acid is far more impeded, or if formed is not exhaled, and the body retains not only useless, but injurious material which respiration should have removed. Expired air, therefore, is more injurious than air unrespired, although mixed with the same proportion of carbonic acid.

The chemical phenomenon of respiration may be stated as set forth by Dr. Carpenter.

The air contains 21 parts of oxygen to 79 of nitrogen in every 100 parts, that is by measure ; by weight, the proportion appears slightly altered although not materially so, the proportion of oxygen being 23 to nitrogen 77. In the process of inspiration both are inhaled, the oxygen disappearing altogether as such, the nitrogen returning unchanged. In the act of expiration, the oxygen appears as carbonic acid or water, having united with the carbon or hydrogen found in the system. The action in reference to oxygen is the important process. It is stated that the carbonic acid exhaled is not formed by the union of carbon and oxygen in the one complete act of respiration, but the carbonic acid is

formed at the expense of oxygen previously contained in the blood. The process, therefore, is only carried a little deeper into the system. The conversion is not immediate in the lungs, but the oxygen is taken into the blood and there unites with the carbon, to be exhaled as carbonic acid during a subsequent act of expiration. All the oxygen, however, is not taken into the blood; some of it unites at once with the hydrogen of the fatty matters and returns as water. The quantity of oxygen absorbed is greater on a meat than a farinaceous diet.

The air cells or chambers of the lungs previously referred to are extremely small elastic bags that expand with each inspiration and contract to expel the air. That they are very small may be gathered from the fact that they have been estimated to be from $\frac{1}{70}$ to $\frac{1}{200}$ of an inch in diameter and to number 600,000,000 in all. Taking an average estimate then of their size at $\frac{1}{120}$ of an inch, we gradually arrive at the extent of surface available for the performance of the full effort of respiration. A square inch would contain 14,400 of these chambers, and a square foot 2,073,600.

Carrying on our calculations, we find that these minute bags would occupy a surface of 289 square feet.

Regarding them only as empty bags with the two surfaces in repose touching one another (which can never be the case), there would still be double the amount of surface. Regarded as hollow spheres, the surface would be three times the diameter, so that the actual surface, all the air chambers being fully

dilated, represents a plane whose dimensions are equal to 289 $\frac{19}{54}$ square feet multiplied by three. Taking them, however, only as double we still have a surface equal to 64 square yards.

Compare the surface of the body with the above and see what a marvellous difference is found. Twelve square feet about represents the body, so that the breathing surface of the lungs would be to the body as 48 to 1.

We have seen in the foregoing remarks that oxygen is taken into the blood through the minute epithelial cells of the air chambers and there performs certain functions. The space in the air chambers when all are fully distended should be sufficient to enable a man 5 ft. 8 in. in height to expel 238 cubic inches of air into a spirometer; he would contain more. In ordinary respiration more than 150 cubic inches would remain in the lungs, only a small proportion of such residuum being expired at each act of breathing. Possibly the law of diffusion of gases would facilitate the complete mixing of the previously respired air with the newly inspired, so that a perfect displacement of the contaminated air would take place in the ordinary course of a few respirations; or the elasticity of the chambers would soon effect a change, it being inimical to the health that the air which has performed its chemical functions should remain long in the system. The amount of air passing through the lungs in 24 hours is estimated at 400 cubic feet in a state of rest, 600 cubic feet in exercise, and 1000 cubic feet in severe exertion. This varies scarcely at all from

the amount estimated by Dr. E. Smith as quoted in Kirkes's 'Physiology.' The chemical results vary according to the conditions of the atmosphere. The amount of carbonic acid exhaled is considerably influenced by the degree of moisture in the air ; much more being given off when the air is moist than when it is dry.

The amount of aqueous vapour exhaled during 24 hours has been calculated at about from 16 to 20 ozs. ; but the authorities on the subject allow of a wide margin. Kirkes says from 6 ozs. to 27 ozs., the ordinary amount being about 10 ozs. According to the first information I saw upon the point, I made my calculations by allowing the mean between 16 and 20—namely 18 ozs. in 24 hours, or very nearly an imperial pint ; equal to six tea-spoonfuls in an hour, or one tea-spoonful every 10 minutes. It seems only natural that such a continual perspiration from the lungs should be very materially affected by the condition of the air to be breathed ; and as a matter of fact such is practically found to be the case.

According to Professor Parkes "the blood parts in the lungs with a large amount of water; the inspired air is saturated with fluid so soon as it reaches the air cells ; it is there heated to 98° and receives a considerable addition even if previously charged with as much as it could contain at a lower temperature. The total amount expired will therefore vary with the amount previously in the air, being greater as this was less, and *vice versâ.*"

Now it does appear as if that paragraph really sounds the key note of the science of climate. The

amount from the lungs being greater as the moisture in the air is less, therefore the question of a dry or a moist climate must be of material consequence to the individual.

An imperial gallon, or 160 ozs., contains 277·274 cubic inches of distilled water. Eighteen ozs. therefore will contain 31·19 cubic inches.

The amount of the rainfall of London is 24 cubic inches on every square inch, equal to 13·88 ozs. (within a very small fraction) or almost 14 ozs.

If we consider, therefore, that a man stands on a square foot of ground, he would exhale in one year more than three times the amount of water that would fall on the same space as rain in that time. The rainfall of London, then, being 24 cubic inches, a column of one foot square and two feet high would represent it; the same sized column of condensed aqueous vapour from the breath would be six and a half feet high, or enough to drown the producer.

The above calculations are based upon the information contained in the earlier works on Physiology; later investigations seem to reduce the amount, but at the same time give a very large margin, ranging from 6 to 27 ozs., the ordinary amount being suggested at about 10 ozs.; only suggested, however, there is nothing positive about it. The absence of any decided information on the subject is in itself an argument of the very variable condition to be found in different individuals. If we apply the calculations to the amount of 10 ozs., we still get a column of water one foot square and nearly double the height of the rainfall.

The rainfall varying very much in different places, the humidity of the air being also very variable, we have to study the dew point of each place to estimate what effect the particular air would have upon the lungs.

CHAPTER II.

PRODUCTS OF WASTE.

To appreciate the action of respiration upon our bodies, it will be desirable to consider the wear and tear, or the processes of muscular disintegration and waste which are continually going on.

There are certain compounds in the body which are the products of waste, which are continually being formed, and which it is essential for health should be removed. They are acted upon by the oxygen conveyed to them from the air by the blood, and undergo transformation till the last product of oxidation is formed. The primary compounds in this series are kreatin and kreatinin; the actual chemical formation being, of kreatin $C_4H_9N_3O_2$, of Kreatinin $C_4H_7N_3O$. Before these primary compounds are removed from the system they have to undergo processes of oxidation and be converted, first into uric acid, $C_5H_4N_4O_3$; and then, by the addition of more oxygen and a decomposition of water, a further change in the arrangement of the chemical elements is effected, and urea, N_2H_4CO, the final product of oxidation, is formed.

In health the quantity of this final product which is eliminated from the system is about 400 grains in 24 hours, or even more. It may be decreased with-

out producing marked symptoms for a time, but if not eventually discharged it undergoes a further change (not an oxidation this time) and is converted into ammonia, NH_3.

If we now consider, in their order of sequence, the chemical formulas of this series of compounds, we see that the primary ones have a larger proportion of hydrogen than the others; that kreatin, by being deprived of hydrogen and oxygen in the proportion to form water, H_2O, may be converted into kreatinin. Thus $C_4H_9N_3O_2 = C_4H_7N_3O + H_2O$, consequently the two are nearly identical.

In the next formation there is an increase in each of the elements carbon, nitrogen, and oxygen, but a decrease of hydrogen; so that oxygen (from the air) and hydrogen have apparently again united to form water. The chemical action that takes place in the conversion of kreatin and kreatinin into uric acid is more difficult of explanation unless we consider that nitrogen from the food takes part in it, which is undoubtedly the case. It does not appear possible for nitrogen from the air to be made use of in the processes, because of the dangerous series of compounds it might form. With carbon, cyanogen; with hydrogen, ammonia; with oxygen, nitric oxide.

There is a larger proportion of both carbon and nitrogen in uric acid than in either of the other two If we take two atoms of kreatin, as in the following example, the process might be expressed thus—

$$2(C_4H_9N_3O_2) + N_2 + 2(CO_2) + O_3 = 2(C_5H_4N_4O_3) + 5(H_2O);$$

or two atoms of kreatinin :—

$$2(C_4H_7N_3O)+N_2+2(CO_2)+O_3=2(C_5H_4N_4O_3)+3(H_2O).$$

In the formation of the final product, uric acid into urea, the hydrogen is increased, but the other elements have all decreased. The formula indicating that there has been a further oxidation and some decomposition of water as follows:—

$$C_5H_4N_4O_3+O_3+2(H_2O)=2(N_2H_4CO)+3(CO_2).$$

If a further chemical change is effected by the urea not being eliminated, it would appear as if water, instead of being formed, is again decomposed, as the following equation will show:—

$$N_2H_4CO+H_2O=2(NH_3)+CO_2.$$

If the urea should not be passed out of the system we get a very dangerous train of symptoms of uræmic poisoning, in which the odour of ammonia may be detected in the secretion of the skin, and in the breath. The decomposition taking place in the bladder, the mucus of the latter acting as a ferment in effecting the change; the ammonia (according to one theory) thus formed apparently finding its way into the blood and thence affecting the brain.

The most perfect instance of uræmic poisoning that ever came under my notice was in the case of a sailor in a coasting vessel.

At noon, on the 4th of June, my attention was called to a boat just come to the beach with a man ill from a ship about ten miles out.

The history of the case, as given by his mate (they two being alone on board a vessel of about

sixty tons), was that, as they were coming down channel on May 31st the captain began to complain of retention. It gradually increased till the morning of the 2nd of June, when they were off Swanage. The mate urged him to go on shore to see a doctor, but finally went himself for some medicine for him, and they went on, arriving off Portland the same night. The mate again urged him to go ashore, but he refused, saying they would be at Lyme Regis, his home, by the morning, having a fair breeze. In the morning they were becalmed ten miles from shore, and so remained all day. His sufferings during all this time had been intense. That night he was rambling in his talk. The mate persuaded him to lie down in his bunk, while he himself remained on deck in charge of the vessel. Hearing nothing of him, at 5 a.m. he went to look at him, and found him insensible. He then took a boat, rowed six miles to some fishermen, and got one to return with him to the ship; lowered the insensible man into the boat and brought him on shore, ten miles. The poor fellow was perfectly insensible from uræmic poisoning; he was operated upon but never rallied, and died about 3 p.m. The urine that came through the canula was in a semi-gelatinous state. The odour of ammonia about him was very great. For four days, therefore, this poor fellow was suffering great agony; on the fifth he became insensible. It might naturally have been expected that he had had rupture of the bladder, but such was not the case. The post-mortem examination revealed no inflammation of the peritoneum.

In the series of chemical changes it will be seen what an important position hydrogen and oxygen both have, either in the formation of water, or in its decomposition. The first indication we see is that water is formed as a necessary part of the process of the elimination of waste, but as the chemical action gradually approaches completion, or the formation of the final product, large quantities of oxygen are required; the greater amount being obtained from the air, and a small quantity from the water which yields up the necessary amount of hydrogen to complete the product. Carbon, in the earlier changes, instead of combining with oxygen to form carbonic acid, is taken in increased proportion to form the next compound, and hydrogen unites with the oxygen to form water. In the later action water is decomposed, and carbonic acid is a large result of the complete processes.

If we carry the theory on to the decomposition of urea into ammonia, as suggested by Dr. Owen Rees, or Frerichs, we see again the decomposition of water and the formation of carbonic acid, as if the two were antagonistic to one another, that when water is decomposed carbonic acid is formed; a deleterious product arising in large quantity when a healthful one is lost.

CHAPTER III.

UREA AND FAT.

OXYGEN is conveyed from the breath into the system by means of a substance allied to albumen which has a great attraction for it and other gases. Hæmoglobin is a compound consisting of the four elements with which we have been dealing, together with sulphur and iron (Fe). It will be seen that it makes use of the four elements in altogether a different combination to the products of waste, the exact formula being $C_{54}H_{7\cdot25}N_{16\cdot25}O_{21\cdot45}S_{0\cdot63}Fe_{0\cdot42}$, so that the proportions of sulphur and iron are extremely small compared with the others. It is the great oxygen carrier; and arterial blood is bright red from the fact of the hæmoglobin being combined with oxygen. When it is combined with carbonic acid we have venous blood. If, instead of either oxygen, O, or carbonic acid, CO_2, the compound called carbonic oxide, CO, should be present, the patient dies of asphyxia in consequence of the carbonic oxide combining with the hæmoglobin. The hæmoglobin apparently carries oxygen and carbonic acid without entering into combination with either, but it would appear to act differently with carbonic oxide, and to lose its own distinctive character.

If we refer to the formula of urea, N_2H_4CO, we see the carbon and oxygen in the exact proportions of carbonic oxide, and it only requires two atoms of hydrogen to convert the urea into ammonia and carbonic oxide, $N_2H_4CO + H_2 = 2(NH_3) + CO$; whether such a combination occurs in uræmic poisoning is an undecided point, but the presence of carbonic oxide would account for the death of the patient.

It is objected to the theory of urea being converted into ammonia in the blood that a ferment is required, or said to be required, to produce the action, and there is none in the blood to do it; but great chemical changes take place in the blood as the result of respiration, and where hydrogen is continually playing such an important part, it seems not difficult to conceive that the conversion of urea in the way indicated may be a sequel in the train of decompositions. A further study of urea shows it to us as a combination of two substances, viz.: two atoms of amidogen 2 (NH_2) and one atom of carbonic oxide CO. The element nitrogen has the power of combining with the element hydrogen in certain proportions to form basic compounds. The first combination is one of nitrogen to two of hydrogen, but it may unite with the latter in larger proportions. The compound amidogen NH_2 thus formed cannot exist alone but must be in combination with some other substance. It may readily be converted into ammonia by combining with another atom of hydrogen. Carbonic oxide may thus possibly be displaced from its conjunction with amidogen and set free.

Another view of urea regards it as having the same number of atoms, or the same formula, as cyanate of ammonia. But I cannot reconcile the two in my mind as synonymous. If it were so, the decomposition of urea in the bladder and the ammoniacal smell in the breath would imply the presence of free cyanogen, which must be fatal. In the case related, if the urea had been converted into ammonia and cyanogen, death would have taken place much sooner. Uric acid and urea may both be found in the condensed watery vapour of the breath, the former in considerable quantity, the latter as an infrequent product; but that they should be there at all is sufficient evidence of the important part that water holds in the act of respiration.

We have before seen that an atmosphere saturated with moisture checks the chemical formation of water in the minute epithelial cells, because so little more water is capable of being exhaled than was inspired; and the less chemical formation of water there is, the less uric acid would be able to escape with it, and the greater would be the work thrown upon the kidneys. We shall see that kidney diseases are more frequent in a moist atmosphere than a dry.

We may still further pursue the inquiry of the effect of respiration upon the animal tissues in the consideration of it in connection with fat.

A person with a tendency to form fat I have known to have the fat to a very great extent removed under the influence of a mountain residence where ozone was a constant constituent of the air. The explanation of it appears simple.

The conditions for the process are perfect. An atmosphere supplied with condensed oxygen, and dry. A dry air conduces to the uniting together of oxygen and hydrogen in the system to form water.

Some time ago I was consulted by a lady in reference to the, to her, disagreeable fact that she was getting very stout owing to her inability to take walking exercise, or even to get very much into the open air. Acting on the idea suggested to me by the effect of mountain air I prescribed a remedy that appeared likely to convey oxygen easily into the system. Without much faith, I am afraid, to begin with, she persevered for some time in doing as she was advised ; before very long she was satisfied that there was a decrease in her proportions, and was a little disposed to find fault for not having had the advice given to her earlier.

Chemically, fat consists of three elements, carbon, hydrogen and oxygen. The atoms of each so arranged as to form different kinds of fat and oil, but their general arrangement being very similar.

Take the particular combination called olein ; its chemical formula is $C_{57}H_{104}O_6$, and though each element may vary in the amount, the proportion in other forms remains very nearly in the same ratio; a large quantity of carbon and hydrogen and a small quantity of oxygen.

According to Lehmann less carbonic acid is given off from the lungs in a dry air than in a moist, but the contrary takes place with regard to water. Thus hydrogen, a very important constituent of fat, would be removed by respiration in a dry air. A mountain

air would also contain less carbonic acid than air at the sea level, and although the oxygen might be expected to, and in fact would, be taken up to form water, still there would be facility for some of it to be conveyed into the system, where it could unite with the carbon to form carbonic acid ; absence of the latter in the atmosphere aiding its exhalation in the breath.

Dr. Ringer says " under exertion, enormous quantities of carbonic acid are exhaled from the lungs, pointing indubitably to the combustion of carbo-hydrates, or of fatty substances, the urea at the same time not being increased." We have it therefore thus admitted (if such proof were necessary) that the fats are burnt up, or used by combination with oxygen ; and it needs no argument to show that the more the oxygen the greater the combustion.

Of course there must be care and caution observed in this as in all matters relating to the health. The late Lord Elgin, Governor-General of India, lost his life in the Himalayas from not being able to undergo exertion in so rarified an atmosphere.

CHAPTER IV.

ATMOSPHERIC PRESSURE.

It is well known that the atmosphere at the sea level exerts a pressure equal to 15 lbs. on every square inch of surface, and that as we ascend into the air the pressure diminishes, till at 3 miles high it is reduced to one half. With these two points to start from it is not difficult to ascertain the amount of pressure at different elevations, and, as a matter of fact, the pressure decreases by half a pound for rather less than a thousand feet; for the first 1000 feet it decreases in greater proportion. We may thus calculate what would be the effect upon the human frame of a diminished pressure of half a pound on every square inch of the human body.

Estimating the surface of the body at 12 square feet, it will be easily seen that such diminution of pressure means a decrease of 72 lbs. on every square foot, or 864 lbs. on the whole surface. Consider the effect upon the frame, or consider it first on the chest and lungs. We know that the lungs are contained in a cavity that is air-tight; that no air can enter it but through the air passages, and that the pressure of the air expands the lungs and raises them against the inside of the chest walls. Supposing the chest to

be 32 inches round, and on an average 8 inches in depth, there would be a surface of $32 \times 8 = 256$ square inches. On ascending a hill 1000 feet in height the atmospheric pressure will be decreased by half a pound on every square inch, or 128 lbs. on the chest alone. As a natural consequence of this the ribs will expand with greater freedom, and inspiration consequently be performed with greater ease. It has been argued that respiration will not be performed any easier because of the rarified state of the air; that it will enter the chest in smaller volume. It does not appear to me that such an argument will hold good. We are taught that nature abhors a vacuum, and consequently, on the expansion of the chest by the effort of inspiration, the air will rush in through the unimpeded air passages; and we shall see subsequently that nature provides a compensating influence in the rarified atmosphere to meet the decrease in the quantity of oxygen.

Supposing the patient to ascend to a higher level, to 2000 feet, the pressure will be decreased by 256 lbs. on the chest; if to 4000 feet to over 500 lbs. It no doubt would be easily possible in the case of very delicate lungs to ascend to a height that would produce actual injury by forcing the delicate structures too much. Even a moderate height, that would be only elastic and invigorating to healthy structures, might be very detrimental to organs already diseased. That this decrease of pressure is an actual and potent power, has been proved when great altitudes have been reached, the lessened pressure on the surface of the body causing the minute blood vessels of the

more delicate parts to gradually become so dilated, from the want of the restraining influence, that bleeding has occurred from them.

We have evidence then of the effect of lessened pressure at certain elevations. Have we any evidence of the effect of pressure at the ordinary sea level?

In their work on 'Pathology,' Drs. Wilks and Moxon, speaking of lung tissue, say, "during certain changes in lung, the tissue surrounding a bronchus contracts and the bronchus is drawn out of shape and distended; also during the same contractile process the walls of the chest are drawn in."

Where does the power come from that "draws in" the walls of the chest? The muscular power for expanding the chest is greatly in excess of that for drawing the ribs in, and the actual factor in the action is atmospheric pressure. "The tissue surrounding the bronchus contracts and the bronchus is drawn out of shape and distended." Why? During the act of respiration the walls of the chest are raised and the cavity enlarged, air rushes in, but being impeded in its course by the contracted tissue it exerts undue power on the part immediately above and gradually causes it to dilate. "Also during the same contractile process the walls of the chest are drawn in." Here again is an illustration of the action of atmospheric pressure. Owing to the diseased and contracted state of the internal tissues when the effort of respiration is made it is abortive; air cannot rush in to occupy the intended space, the ribs are pressed upon by the external air, and prevented from rising; there is not sufficient elasticity

and power inside the cavity of the chest to resist the pressure on the outside. At every effort of respiration the process is repeated, gradually the walls of the chest are pressed in, not drawn in. Of course this action occurs over the diseased portion of the lung, and we naturally find that the upper portion of the chest is flattened, because it is the upper portion, or apex of the lung, that is most frequently the first to show the disease.

Take again the case of the child with mechanical impediment to respiration through obstruction by enlarged tonsils. Here the lungs are healthy, but the sides of the chest become flattened because the air cannot pass in quickly enough to occupy the intended space during each inspiration. The result is that the child becomes pigeon-breasted.

The following quotation from Dr. Marshall is sufficient evidence to the point:—

"During life, the lungs are in contact with chest walls, they offer strong resistance to the equilibrium of atmospheric pressure, the air entering the lungs through the bronchial tubes expands the elastic tissues of the lung and presses them against the inner surface of the walls so as to endeavour to complete the balance inside the chest with the pressure on the outside."

Turning to the 9th edition of Carpenter's 'Physiology,' by Dr. Power, we find a reference to the effect of increased pressure.

Experiments in America.—Men exposed to pressure of 50 lbs. to square inch, exclusive of ordinary atmospheric pressure of 15 lbs. to square inch. No

ill effects observed while men were working in the air chambers, but on suddenly emerging, great exhaustion, pain in epigastrium and spine, paraplegia, and even death occured.

An increased pressure of 50 lbs. to the square inch means something enormous on the whole body; the effect, when the pressure was taken off, must of necessity be extreme.

In the above quotation, Dr. Marshall especially refers to the necessity of equilibrium between the outside and inside.

It becomes a question then of calculation as to the elevation a patient may require whose lungs are becoming diseased and the chest walls flattened. Too high a position in the Alps may be as injurious as too near the sea level. We have seen that excessive elevation will cause hœmorrhage from delicate though healthy structures; a much less height might very easily cause it where the delicate structures are diseased, and yet a moderate one be most advantageous.

The following points are thus brought under our notice and have to be considered. The atmospheric pressure; the chemical condition of the air; and the mechanical purity of it. No doubt much benefit is obtained at the seaside and on high ground from the absence of dust, spores, and other floating particles.

CHAPTER V.

THE WATERY VAPOUR OF THE BREATH.

In order to be able to examine and test the aqueous vapour of the breath, I condensed it by causing the breath to pass through a bent glass tube. The tube was made to describe two circles, so that as long a piece of the glass as possible should be exposed to the influence of cold by resting in a vessel containing cold water; iced water if necessary. The tubes were made for me by Messrs. J. J. Griffin & Co., and had a bulb at the lower part of the second curve to facilitate the collection of the condensed vapour. I do not intend to convey the impression that I was able to condense all the vapour, because it was not at all likely that such would be the case. Anyone, however, trying the expedient will soon see how short a time it takes to collect sufficient to experiment upon. I estimate that from one to two drops a minute may very easily be obtained.

Having collected a small quantity, I placed some under the microscope with a $\frac{1}{8}$ power. Perfect specimens of pavement epithelium were what first attracted my attention; sharply defined, evenly constructed six-sided plates; the edges of some were most clear and distinct, not exhibiting the smallest irregularity;

others were smaller, and apparently torn from their attachments. Three or four can frequently be seen on each slide.

There was also a considerable quantity of amorphous deposit, very small, having the characteristic colour of uric acid.

According to Professor Carpenter, water from the lungs contains "uric acid, urates of soda and ammonia, chloride of sodium and ammonium. But a far more important product, which seems to be an albuminous substance in a state of change. If the vapour be condensed in a closed vessel and warmed, a putrid odour is exhaled."

I have always condensed it in a tube open at both ends, and therefore not under the conditions above mentioned. However long the water has remained in the tubes, or stored in a glass-stoppered bottle, I cannot say I have ever detected the odour on warming, except on the addition of liq. potassæ. I gather from this that oxygen speedily acts on the albuminous substance and converts it.

Dr. E. Smith found, during a long fast, vapour exhaled equal to 2·02 grains per minute; or ·584 grain in every 100 cubic inches of expired air. With food and at rest the quantity varied from 3 grains to 3·4 grains per minute. The watery vapour holds in solution carbonic acid, and also some animal matter, that is, albuminoid substance, a small quantity of ammonia, chlorides of sodium and ammonium. Occasionally urea. He also says, "Among substances occasionally thrown off by lungs, phosphorus deserves attention. Luminous breath has been observed in

spirit drinkers in whom the oxidation of effete materials of system is impeded in consequence of demand set up by the alcohol, C_2H_6O, ingested for the oxygen introduced."

The detection of ammonia by the Nessler test is of course simple; the colour, light amber, is most distinctly perceptible, the shade being an index of the amount of ammonia present. From the remarks upon the products of waste, it might naturally be supposed that a considerable knowledge of the condition of those products would be indicated by the evidence of the amount of the ammonia and uric acid present. I have found that the uric acid in the breath varies in quantity in the same individual at different times, and when present in increased quantity would imply an imperfect state of oxidation in the system.

I have tested the condensed vapour from the breath of a diabetic patient with the picric acid test.

Although there were only a few drops of the water to be tested, a decided colour was produced, different from that produced by boiling picric acid and liq. potassæ alone. I did not see any indications of albumen before the liq. potassæ was added. The amount of sugar in the urine was ten grains to the ounce. In my trial I carried out the instructions in Dr. Johnson's 'Albumen and Sugar Testing.' On allowing the mixture to stand for several days, crystals formed, which, on being placed under the microscope, looked something like the illustration of pulmonic ac d in Beale's 'Microscope in Medicine'; or needles radiating from a centre. They were possibly crystals

of picrate of potash, but they did not have quite the same appearance.

Condensing the watery vapour and collecting ammonia at the same time on a glass slide, I obtained beautiful crystals of chloride of ammonium, and decided colour with the Nessler test in the water collected.

With permanganate of potash dissolved in distilled water and added very carefully so as to gradually fall through the fluid, the colour disappeared very quickly. The quantity necessary to maintain a steady colour, compared with the amount to be acted upon, can easily be regulated.

CHAPTER VI.

OZONE AND ELECTRICITY.

The 'Journal of the Scottish Meteorological Society' for January and April, 1872, has the following remarks upon ozone:—

"When the air had a pleasant sharpness to the feelings, exercising, as it were, a stimulating influence on the spirits, the largest quantities of ozone were obtained. On the other hand, when the air was close, and seemed to exercise a slightly depressing influence, little, if any, ozone was detected."

In mountainous regions, especially in those countries where there is a continuance of bright, dry air, ozone may always be expected, and when present must exercise a great influence on the bodily frame, and, as a consequence, on the health.

In the above extract when the air had a "stimulating influence on the spirits" ozone was always present. It is therefore a most important point to investigate as to what positions, and under what circumstances, ozone can be found.

During a residence of eighteen months in the Himalayas, I repeatedly exposed slips of test paper for ozone, and never failed, when the air was dry, in

detecting it. A very short exposure was sufficient to obtain decided evidences of its presence.

In the West of England on the South Coast, on the contrary, I found it an extremely rare thing to be able to get any colour on my slips of paper. At the edge of the water, with the wind blowing off the sea, I have repeatedly tried and failed. Away from any pernicious influence of drains, with the greatest wish to be able to demonstrate its presence, I was seldom able to do so.

Ozone used to be described as oxygen in another form, as having undergone a peculiar, but unexplained, process which affected its properties while in its altered shape, but which did not prevent it from returning to its original and primitive condition. On the principle that all grapes are not red, so oxygen, it was said, had not always the same appearance, its action not the same, and, in its new form, having obtained an odour which it had not in its natural condition. In saying that its action was not the same it would have been perhaps better to say that its powers and properties were increased and exaggerated. More recent investigations have led to the theory, by Dr. Odling, that ozone is condensed oxygen, three atoms of the element being compressed into two, and that in this form it is continually seeking for a material which will enable it to escape from its enforced bondage and return to its natural state.

The most recent idea represents ozone as a combination of hydrogen and oxygen, a very small quantity of the former being added, the formula

being H_2O_3. It must be borne in mind that the quantity of hydrogen is very small, the combining proportion of it being 1, whilst oxygen is 16. Consequently ozone, H_2O_3, means that there are two atoms of hydrogen and 48 (16×3) of oxygen. It is still therefore presented to us in a condensed form, in which it is ever seeking for a medium to restore it to its own shape.

The one thing which offers itself as the most suitable for the purpose is decaying matter, animal or vegetable, the extra atom of oxygen in the ozone instantly seizing upon the deleterious product to purify it; the remaining two atoms reverting to oxygen pure and simple. What happens to the hydrogen under these circumstances does not appear to have been satisfactorily explained. Ozone becomes thus a most important item in the economy of nature, and, in due proportions, a most valuable agent in our human economy.

Like a great many other things which are valuable to us, it may be overdone; may be present in too large a proportion to the decaying matters to be purified; and not finding sufficient suitable material to absorb its energies, and having a great readiness to enter into chemical combinations, it will, if respired, act upon the mucous membrane and epithelial cells of the air passages in too vigorous a manner, and cause irritation and distress as a consequence.

Consumption in the Hebrides is said to be very prevalent from this cause. It remains to be investigated what effect would ensue in the human subject if ozone were respired for a long period in an excessive

quantity, although not in sufficient to produce an immediate and palpable effect on the air passages. According to Dr. Fox ('Ozone and Antozone'), "periods of ozone and seasons characterized by an increase in the amount of febrile diseases do certainly seem to correspond with each other."

Some years ago, when in Central India, the troops under my charge suffered intensely from jungle fever. It was always a question in my mind as to the cause. Decaying vegetation was accused of the offence, but I had to confess to myself that the fever commenced before the vegetation began to decay.

We were encamped on ground with a reddish soil and a rocky substratum, but it was of comparatively small area. The great mass of the country surrounding us was a black soil of a spongy nature, with scrubby underwood very sparsely spread over it. During the dry, hot weather this black soil cracked into fissures eight or ten inches wide. As soon as the rains set in a dense growth of weed commenced, which rapidly attained a height of nearly six feet. Before this growth was complete, fever began.

One of the sources of ozone is the growth of plants; rain is another (and how it did rain). Was ozone the cause of the illness? Could it have been that ozone was present in a poisonous dose? A very noticeable effect of the fever was the rapid and enormous enlargement of the spleen; in many cases it stretched across the abdomen two inches beyond the medium line.

Professor McKendrick says that "in excessive quantities ozone diminishes the number of respirations

and the blood is found in a venous state." Such being the case we may possibly see an explanation of the enormous enlargement of the spleen.

Although the blood is thus stated to be in a venous state when ozone is in excess, there are the experiments of Dr. Richardson proving that putrid blood is purified by it. It would appear, therefore, to be a question of amount, and its action on the respiration.

A natural constituent of the air, having influence in quieting the action of the heart, would, in many cases, be a most valuable aid in treatment; but it must be in right and due proportion. The growth and vigour of plants is impaired by too much ozone in the air; in certain cases, therefore, when it is desirable to check parasitic, such as fungoid, growths, it should be of immense assistance.

Ozone and electricity appear to be intimately associated.

Dr. Shapter, speaking of ozone more than twenty years ago, says "that little else than a few general observations can be advanced in reference to it. Nor, as far as I am aware, have there been any corresponding observations of the electrical condition of the air, which from the agency of electricity in converting oxygen in this, the allotropic state, would appear to be necessary to make the elucidation of the subject satisfactory."

The galvanic battery is redolent of ozone; the human body, under the influence of dry air and ozone, becomes demonstrative of electricity. At an elevation of 5000 or 6000 feet on the Himalayas the

least friction will manifest its presence. Brushing the hair has the effect of causing it to stand erect. Combing the beard produces, in the dark, bright flashes of electricity, and such is the sensitiveness of the skin that the act is quite painful.

In the mountains this manifest electrical condition of the body was present at the same time that the air was full of ozone. Is this free electricity the result of the dryness of the air, and the presence of ozone only a coincidence, or is the free electricity developed by the action of the ozone? The two appear to be most intimately associated. Ozone, we know, is set free in the air by the presence of electricity; and electricity is manifest in "proportion to the activity with which vital processes are carried on." Therefore, the more perfect be the purity of the atmosphere the more active will be the chemical processes in the body. In this way ozone would have the effect of setting free the latent electricity.

It has been already stated that ozone is a condensed form of oxygen; its great power depending on the ease with which it parts with its third atom. When respired in continuous small doses it would be decomposed (in the blood ozone loses its properties), the oxygen resulting being available for use in the lungs. In elevated situations, with the atmosphere thinner than at the sea level, this supply of oxygen would be of great assistance in the process of breathing. During the decomposition there would be electrical disturbance.

I think I may say that all the writings I have been

able to consult testify to the presence of ozone and electricity in elevated situations; both increasing in proportion to the height. Referring again to the 9th edition of Carpenter's 'Physiology,' it states that "no two parts of the body (save those which correspond on opposite sides) have electrical condition the same," and "the differences are greater in proportion to activity with which vital processes are carried on."

Donnè says "that the skin and most internal mucous membranes are in opposite states. Parts undergoing molecular change give rise to electrical disturbance. Men of sanguine temperament have more free electricity than those of phlegmatic character."

I have taken the liberty of giving these quotations because they all so fully bear out to my mind the necessity of carefully considering the particular change of air which each individual may require. Under the influence then of a continuous dry air, the electrical condition of the body is disturbed. When the weather is close and oppressive, in other words, more or less loaded with moisture, there is a deficiency, almost an absence, of ozone, and the languid state of the body accompanying such an atmospherical condition is incapable of demonstrating any electrical activity.

"In excessive quantities ozone produces irritation of the air passages, diminishes the number of respirations, and the blood is found in a venous state" (McKendrick).

In my experience in the Himalayas, the quantity was evidently too small to produce toxic effects. Men who had suffered from jungle fever, liver and dysentery, remained in good health all through the winter months.

CHAPTER VII.

ANIMAL ELECTRICITY.

I HAVE been in the habit for a long time past of employing the electroscope in studying the condition of the body.

It has been, and I may say is, regarded simply in the light of a toy, and as such I first began to use it; but it was not long before it seemed to me to be deserving of more appreciation. When I saw the two slips of gold leaf gradually separate on approaching the hand towards the brass disc, although the instrument was not brought into contact, it seemed to indicate something beyond the mere philosophical plaything. There was then present a state of the body which was not always persistent. It was only under certain atmospheric conditions that that action from the hand was demonstrable. At other times no effect whatever was produced. The separation of the gold leaves arises from the presence of free electricity, either positive or negative, it matters not which, and this free electricity can only be present when there is a disturbance of the balance, when there is a decomposition of the electricity and the two elements, positive and negative, no longer neutralize one another.

Electricity, according to recognised authorities, is universally present in nature, but it is in that condition when its positive and negative are combined, and in which it is unable to exert any influence. The living body is full of electricity. Dr. Radcliffe says that "each perfect fibre and cell of living muscle and nerve (and, by implication, every fibre and cell) is a charged Leyden jar while at rest;" and further states that during action it is discharged and loses nearly, but not all, its positive electricity. I say then that the hand, under certain conditions of the atmosphere, at the distance of an inch from the brass plate of an electroscope, will cause the slips of gold leaf, hanging within the glass bell, to separate; that on withdrawing the hand and again advancing it, without touching the apparatus, the slips will close and again divide with such movements. There is, then, a certain condition of the body which will act on the gold leaf. There is also one which has no power over it; this latter being by far, in this country at least, the most frequent condition.

A non-conducting substance under the influence of friction has its equilibrium disturbed, and becomes charged with free electricity, positive or negative, and if brought near to the brass plate will cause the gold leaves to separate; the two slips become charged with the same kind of electricity and repel one another. There is, then, a similarity between the human body and the non-conducting substance under friction, but the former is only occasionally capable of proving the similitude. It therefore seems to follow that there is a varying electrical state of the body,

and it would appear only reasonable to suppose that the bodily vigour and health are thereby affected. The question very naturally follows, are people affected by electrical disturbances in the air? I think most decidedly the answer must be in the affirmative. Very many people are conscious of headache and lassitude under electric disturbance; their own latent electricity being disturbed by the atmospheric phenomenon.

A gentleman frequently complained to me of headache and great general discomfort before a thunderstorm; even on many occasions when the storm has been at a distance, he still, to a greater or less degree, experienced the same sensations. That it was not simply a variation of atmospheric pressure which affected him was shown by his not complaining, or seeming to experience, any uncomfortable feelings with a low barometer and a heavy gale, or the exceptionally low barometric pressure which occasionally presages a severe snowstorm. Many people experience very uncomfortable feelings in a thunderstorm from extreme nervousness, but this was not the explanation in his case; nothing, I may say, pleased him more than to watch the sublime effects of a brilliant storm.

Carpenter relates the case of a lady who for months was in an electric state in which sparks passed between her and any object she approached, at a distance of an inch and a half. Contact therefore was not necessary in her case. She experienced pain at the same time. He also mentions another case.

Speaking of electric animals, he says "the power of

the animal over the actions of its electric organs is dependent upon the connection with the nervous centres."

Quain says "nerves are distributed to the coats of arteries, probably for governing their contractile movements. The nerves come chiefly from the sympathetic, but also from the cerebro-spinal system."

Professor Carpenter says also, "it is now well ascertained that one of the most important functions of the sympathetic is the regulation of the calibre of the blood vessels, by the influence of its nerves on the muscular fibres contained in their walls."

There are, then, nerves exercising an influence over electric organs as one part of their functions, and controlling the calibre of blood vessels as another part; may not the calibre of blood vessels be very much influenced by the condition of the electricity always present in the frame?

From the opening quotation of this chapter we see that air in which ozone is present has a stimulating feeling on the spirits. But ozone has such an intense affinity for decaying matter, and the lower forms of life, that it speedily exhausts itself in overcoming them. With the exhaustion of the ozone there is also the loss of electrical activity in the frame; there is no friction, so to speak, from the air upon the body, so that the functions, in a measure, sleep. The sympathetic nervous system performs its duties in a sluggish manner. The great centre of the sympathetic is the solar plexus with its vast controlling power over the vessels of the abdominal viscera. But what is the result when the air is impregnated with

decaying matter so that all ozone is destroyed, and the decaying matter is rampant? Or it may be a peculiar state of the atmosphere, from whatever cause, when electricity and ozone are not only deficient, but practically absent through the latent condition of the former? There is, then, an utter absence of control by the sympathetic; the blood vessels, not being under any restraining influence, pour out their contents like water.

Fremy says ('Journal of the Meteorological Society'), "when electrical tension is low, as in cholera years, the proportion of ozone is relatively low." During the days when cholera was worst at Turin, electricity was almost entirely wanting. If these statements concerning the electrical tension are correct, then it would appear to be a consideration of how to destroy, if possible, the equilibrium, and produce free electricity; how to cause sufficient concussion in the atmosphere to form ozone. Movement of air produces it, and therefore land and sea breezes are important factors.

Scoutetten states that ozone may be produced in air by electrical phenomenon acting on its oxygen.

There would appear to be little difficulty in supplying ozone to small areas, such as rooms and houses, because Bottger states that a mixture of strong sulphuric acid with permanganate of potash will give off ozone for months. Dr. Burney Yeo, in an address delivered before the West London Medico-Chirurgical Society, on Bacillus of Tubercle (unless my memory greatly errs), spoke of the antiseptic properties of ozone, and the advantage it would be

to tuberculous patients to breathe an atmosphere where ozone was present in due proportion.

To have any curative effect it must not only cleanse the atmosphere the patient breathes (that would be preventive of infection), but must actually act on the micro-organisms in the air passages. In lofty heights, with a continual presence of ozone, the body, in a state of electrical tension, must be in a very different position for resisting the encroachments of disease from its condition in a town where ozone, if present, is in such a minute quantity that it cannot be detected.

The conclusions arrived at by these remarks are that in high altitudes, in dry air, ozone is always present; that ozone is due to the disturbance of the equilibrium of electricity in the air, therefore electricity is always present; that the continual presence of electricity and ozone has a marked influence on the human frame. Electricity is also always present in the body in a quiescent state; the result seems to be that electricity in a high state of tension in the atmosphere disturbs the equilibrium of it in the body and free electricity is the result.

There is a reason, then, for sending phthisical patients to a properly dry and elevated station.

There is an electrical condition of the atmosphere which produces ozone; there is a condition of free electricity in the body, which invigorates the nervous system; there is ozone exercising its antiseptic properties in the air passages of the lungs and destroying bacillus; there is the restored controlling action of

the nervous system, exercising its influence over the calibre of blood vessels; there is the difficulty of breathing in a rarified atmosphere compensated for by the increased supply of oxygen owing to the conversion of ozone during respiration.

CHAPTER VIII.

CLIMATE AND TOPOGRAPHY.

We now come to the consideration of climatic conditions.

Turning to the reports of the meteorology of England by Professor Glaisher, we obtain a great deal of information on the point; but before doing so I would refer to the account of South Devon by Dr. Shapter.

One of the indications more particularly to be observed is the dew point, as from it we gain an immense deal of information. The greater the difference between the dry and wet bulb thermometers the drier will be the air. The observation of these two thermometers, without troubling very much to calculate the dew point, is what we have to do.

Dr. Shapter gives a table of every month in the year for ten years, with the result that, on an average of the whole period, the general daily difference was less than three degrees. As might be expected July gives the greatest variation between the two, a little over five degrees; October, November, December, January and February are all less than two degrees, so that the air must be fairly full of moisture for the evaporation of water round the wet bulb only to lower the temperature to that extent.

During twelve months I made and recorded observations at Lyme Regis, the difference between the two thermometers was not more than three degrees on an average; frequently the difference was not more than one degree, and if such was found to be the case we might prepare for rain. At other times it might reach to nearly six degrees, but they were very rare occurrences.

The constant presence of moisture in the air has, according to Dr. Shapter, a marked influence on the prevailing disease of the district, and results in what might be expected, namely, an increase of kidney affections and dropsy.

My own experience for many years led me to the same conclusions. That it is what might be expected is a natural deduction from the results of our previous enquiries upon the products of waste.

In a moist air there is much less chemical action, as the result of respiration, than in a dry; there is less formation of water, which entails a difficulty in the first transformation of the products of waste, water being a necessary consequence of the process. Anything therefore that tends to hinder that action throws more work upon the kidneys. One at least of the primary products, kreatinin, is found to be passing through the kidneys without having undergone the complete natural oxidation; there is consequently extra work thrown on the kidneys to perform, and the effect eventually is that they fail under the continued effort and become diseased.

Dr. Shapter says "idiopathic dropsy is rare. How far this prevalence of a colliquative dropsy is

due to the moisture of the climate is difficult to determine. It is, however, a common belief that dropsy is more frequent in places where the atmosphere is generally charged with moisture; the theory of which is, that a climate of this nature produces a preternatural fulness of the blood vessels, by retarding the flow of blood through the veins; hence (assuming such to be a predisposing state of the system) upon any defect arising in the compensating functions of the kidneys, or *other excretories of the animal fluids*, dropsy ensues." (The italics are mine.)

He is careful to point out that these cases are not the result of excesses on the part of the population.

Why should there be a "preternatural fulness of the blood vessels by retarding the flow of blood through the veins?" Does it not directly point to incomplete oxidation?

Though we have seen that in a moist air carbonic acid is formed and exhaled in greater proportion, yet it would appear, from the above remarks, that an atmosphere conducive to the formation of water in the lungs, and its exhalation, is greatly advantageous to the maintenance of health, and the easy performance of their functions by the different organs.

It may possibly be argued that a moist air would produce a freer action of the skin; but should it apparently do so, the consequence of such action would be to draw off a certain amount of fluid without compensating in any way for the drainage by chemical action.

What I would endeavour to impress is this. In

seeking a change of air it is desirable to consider the atmosphere which has been breathed for a time, so that a different condition shall be presented to the lungs. Energies that have been exerted in one direction be allowed to rest, and another set brought into play.

For example. Carbonic acid is formed gradually in the body by the circulation, and is not the immediate result of respiration. It is most completely exhaled in a moist air previously free of the compound. In such an atmosphere, as we see in Devonshire, the kidneys are liable to be affected. Some water is chemically formed in the lungs as the immediate act of one respiration. It is most completely accomplished in a dry air. It carries out with it certain products which it obtained from the blood. The oxidation which is effected is sharp and decisive.

The meteorological tables give the results of observations carried on at different stations all over England, and one station, Llandudno, in Wales. They do not contain information from any place in Scotland.

As regards moisture the register of the wet bulb thermometer is not stated, the calculation having been made and the dew point given. A very unscientific way of arriving nearly at the wet bulb would be to halve the difference of the temperature of the air and the dew point; thus, dry bulb 59·5, dew point 50·2, halfway between the two 54·85 as the wet bulb. Carrying out the calculations with precision, however, we find that, in order for the dew point to have been 50·2, the wet bulb must have been 54·9.

Again, with the temperature altogether lower, we get a close approximation to the wet bulb. Thermometer in air 43·3, dew point 38·3, difference 5·0; halving the difference we get an estimated wet bulb 40·8, the actual condition of the wet bulb was 41·0.

Seeing, however, that the farther from the temperature of 55·0, either higher or lower, the greater the error in the rough and ready way, and not feeling satisfied, I calculated the wet bulb for the following tables. They may not be absolutely correct, but they are as nearly so as the data would allow.

Records of August, 1883.

Feet above the Sea.	Place.	Thermometer. Air.	Thermometer. Wet Bulb.	Difference.	Humidity. Saturation =100.	Rain. Days.	Rain. Inches.
69	Plymouth . . .	59·9	56·8	3·1	84	12	1·01
80	Ventnor . . .	61·5	57·7	3·8	79	11	0·72
159	Royal Observatory	62·0	57·5	4·5	76	10	0·71
123	London	62·4	56·8	5·6	71	10	0·93
89	Lowestoft . . .	59·7	55·6	4·1	77	12	1·03
39	Holkham . . .	58·4	54·5	3·9	78	8	1·12
100	Llandudno . . .	58·5	55·9	2·6	83	13	1·82
530	Halifax	57·0	53·0	4·0	75	11	1·63
114	Carlisle	56·7	54·3	2·4	85	18	2·68

Record for November, 1883.

Place.	Thermometer. Air.	Thermometer. Wet Bulb.	Diffe-rence.	Humidity. Satu-ration =100.	Rain. Days.	Rain. Inches.
Plymouth . . .	46·0	44·7	1·3	91	24	4·47
Ventnor. . . .	47·6	45·0	2·6	82	19	5·24
Royal Observatory	43·8	42·2	1·6	86	21	2·84
London	43·8	42·1	1·7	85	16	2·78
Lowestoft . . .	43·3	41·6	1·7	85	21	3·50
Holkham . . .	41·9	40·6	1·3	89	19	3·14
Llandudno . . .	45·7	42·3	3·4	81	19	2·71
Halifax	40·5	39·2	1·3	86	19	4·66
Carlisle	41·4	40·1	1·3	95	23	3·96

Record for February, 1884.

Place.	Thermometer. Air.	Thermometer. Wet Bulb.	Diffe-rence.	Humidity. Satu-ration =100.	Rain. Days.	Rain. Inches.
Plymouth . . .	44·0	42·4	1·6	89	21	4·04
Ventnor. . . .	44·6	43·0	1·6	87	16	2·29
Royal Observatory	41·9	40·2	1·7	85	13	1·50
London	42·0	40·2	1·8	85	14	1·40
Lowestoft . . .	41·6	39·7	1·9	84	11	0·83
Holkham . . .	40·0	39·0	1·0	91	8	0·50
Llandudno . . .	42·8	40·7	2·1	82	19	2·98
Halifax	38·8	37·6	1·2	88	18	4·28
Carlisle	40·8	39·1	1·7	84	14	1·40

Record for May, 1884.

Place.	Thermometer. Air.	Thermometer. Wet Bulb.	Thermometer. Difference.	Humidity. Saturation =100.	Rain. Days.	Rain. Inches.
Plymouth . . .	51·6	45·8	3·1	79	10	1·0
Ventnor. . . .	53·0	49·5	3·5	77	9	1·2
Royal Observatory	54·3	49·4	4·9	71	10	·96
London	54·2	49·1	5·1	67	11	·78
Lowestoft . . .						
Holkham . . .	49·8	46·6	3·2	78	7	·80
Llandudno . . .	51·7	47·9	3·8	74	7	1·35
Halifax	50·0	44·8	5·2	67	9	1·83
Carlisle	49·5	46·5	3·0	79	12	2·50

Table V.

		Difference.	Humidity.	Rain. Inches.
Ventnor . .	August, 1883	3·4	79	0·72
	November, ,,	2·8	82	5·24
	February, 1884	1·9	87	2·29
	May, ,,	3·5	77	1·12
Holkham . .	August, 1883	3·5	78	1·12
	November, ,,	1·7	89	3·14
	February, 1884	1·3	91	0·50
	May, ,,	3·4	78	1·35
Llandudno .	August, 1883	2·4	83	1·82
	November, ,,	2·9	81	2·71
	February, 1884	2·7	82	2·98
	May, ,,	4·0	74	1·35

Comparing Plymouth with Carlisle in August, 1883, we see three degrees difference in temperature, and 0·7 difference in the relative dryness, the former being slightly the drier air. The fall of rain was as two to three in the number of days, and one to two and a half inches in amount. The humidity is practically the same in both places. If Plymouth had had as many days wet and as much rain we might have expected to see the humidity much higher.

Holkham and Llandudno occupy nearly parallel positions on the East and West coasts; the air of the former was drier, but it does not appear to be generally the case.

Comparing the four returns, we find London drier than any of the nine towns, taking the year all through; but Halifax, an inland town lying high, is slightly drier in the spring.

Glancing down the columns in the Quarterly Reports for twelve months from July 1, 1883, to June 30, 1884, we see only once the humidity anywhere, in all the 43 places mentioned, as low as 60, and that was at Leeds in the spring in May. The difference between dry and wet bulbs then was 6·8.

The conclusion we might come to is, that some parts of Yorkshire present very favourable conditions for people seeking change, especially from moist air.

The information in the reports in reference to ozone is very incomplete. There are twelve places where observations are made, but no indications of the electrical tensions are given in connection with it.

Silloth, in Cumberland, appears to have more ozone

than any other place in England. Ventnor is occasionally high.

The climatological observations of the stations of the Royal Meteorological Society contain some interesting and curious information with regard to humidity. Seathwaite, in Cumberland, appears to be the rainiest place in England, with a rainfall of 143·97 inches during the twelve months of 1883. Devonshire is acknowledged to be a rainy country. Many of the places mentioned had from 30 to 40 inches

Ashburton had 55·66 inches, the highest of all the English places, with the exception of Seathwaite. The humidity of Ashburton is given as 85, and Seathwaite 80 per cent. Unfortunately the humidity of Southend is not given, the rainfall was only 19·18 inches. Margate, humidity 82, rainfall 22·27 inches. Regent's Park, humidity 80, rain 23·96 inches.

London and the neighbourhood had less humidity than the rest of England, 78 being the lowest amount. Silloth, near to Seathwaite, had a rainfall of 32·95 inches, humidity 82·5. As rain produces ozone, it is possible that Silloth is indebted to the heavy rain of the neighbourhood for its ozone. It certainly seems curious that Seathwaite, with its immensely greater amount of rain, should have an atmosphere showing less humidity than almost any other place; London being only slightly less.

The change from a moist air to a dry has, in certain cases, a marked and immediate influence on the general condition, as I personally experienced during the past autumn.

While in Devonshire, at the bottom of a valley, close to a river, the feeling of tiredness which I experienced was almost distressing. In Derbyshire, in the Low Peak Country, in the hills round Wirksworth and the neighbourhood of Matlock, no amount of exertion seemed to cause fatigue.

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